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ENGINEERING PROGRESS REPORT
E41R1 POINT SOURCE GAS ALARM

Contract Number

SA-18-108-CWL-6553

for

ARMY CHEMICAL CENTER
Edgewood, Maryland

for

Period of March 20, 1961

Through April 29, 1961

ER-2369

REPORT NO.

May 5, 1961

DATE

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5-5-61

Date

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5-5-61

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I. INTRODUCTION

This report describes the engineering progress of AAI from 20 March to 29 April 1961, on the E41R1 Point Source Alarm. Included herein is a summary of all work performed under contract number DA-18-108-CWL-65553, including the combined effort development program with CRDL for the design and fabrication of the E41R1 alarm and associated equipment.

Work is currently in progress on Phase II and Phase III of the contract program. The Phase II portion of the program is nearing completion and Phase III preliminary operations have been begun. Procurement of components of the six Phase III alarms which are to be built to reflect minor changes to the Phase II design and of the 16 Phase III alarms which are to reflect all the latest (Phase III) design changes is well under way. Research and development studies will continue during Phase III. A set of Class I drawings reflecting these changes will be prepared.

II. SUMMARY OF WORK PERFORMED

The research and development engineering program for the E41R1 Point Source Alarm has progressed as scheduled during the period of 20 March to 29 April 1961. Most of the Phase II effort has been completed and preparations are well under way for Phase III of the contract.

During this period, three alarms were forwarded to Fort Benning for CONARC tests. Engineering personnel from the Army Chemical Center and this contractor accompanied the alarms to render

assistance during the test program. Meanwhile, further research and development tests and engineering developments have taken place in the following portions of the alarm:

- (1) Experimental and original design air pump tests.
- (2) Several areas of electronics have been modified and tested, including the tape transport drive system, radio interference studies, and engineering studies of the low-voltage cutoff, the regulated voltage, and the alarm light oscillator circuits.
- (3) New materials and designs of the fluid pump were tested.
- (4) Improvements to the alarm case to enhance watertightness and ruggedness.
- (5) Investigation into alarm transportability.
- (6) Impact tests and correction of tape drive retraction snubber.
- (7) Development of modified vacuum sensor switch.
- (8) Analysis of photometer head problems regarding the light pipe, the exciter lamp, and the thermistor.

III. DETAILED DISCUSSION OF PROGRESS

A. Phase II Program

1. Class I Drawings

A total of approximately 310 Phase II class 1 drawings were completed and delivered to the Army Chemical Center on

14 April, 1961. This completed the class 1 drawing requirement of the Phase II program of the subject contract.

2. Manufacturing

Five retrofitted alarms which were undergoing pre-delivery tests were diverted for further research and development studies under the Phase II program. Of these, alarms numbered 9 and 17 were diverted for use in tape transport system studies being conducted at AAI, and number 22 for similar studies at CRDL. Unit number 19 is being used for radio noise suppression studies and alarm number 30 is being used for development studies on the electronic system.

3. Documentation

a. Interim Technical Manuals

On 1 April 1961, a total of 22 additional copies of the gas alarm interim technical manuals (revised) were delivered to ENCOM. These manuals consisted of the Operator's and Organizational Maintenance Manual (ITM 3-6665-210-12), the Organizational Maintenance Repair Parts and Special Tools Lists (ITM 3-6665-210-20P), Field and Depot Maintenance Manual (ITM-6665-210-35), and the Field and Depot Maintenance Repair Parts and Special Tool Lists (ITM 3-6665-210-35P).

b. Purchase Descriptions

On 10 April 1961, the approval drafts of the purchase descriptions covering the alarm, the remote warning unit, and the chemical resupply kit were returned to AAI with Army Chemical Corps comments attached. These three purchase

descriptions were revised to incorporate these comments and the reproducible and 35 copies were delivered to ENCOM on 24 April.

c. Component Test Procedures

On 24 April 1961, one reproducible and six copies of component test procedures for the following items were delivered to CRDL:

Over-all alarm tests, including inspection, sensitivity tests, and environmental tests.

Meter-relay tests.

Detection head tests.

Tape drive assembly tests.

Air pump assembly tests.

Solution pumping system tests.

Air flow sensor tests.

Electronic control amplifier (printed circuit board) tests.

Remote warning unit tests.

Alarm horn tests.

Air pump drive motor tests.

Solution pump (timing) motor tests.

Tape transport motor assembly tests.

Thermal switch assemblies S5, S6, and S7 tests.

Air intake heater tests.

Air outlet heater tests.

Wiring harness (installed) tests.

Under the terms of the subject contract, these test procedures will be revised and brought up to date to reflect the latest engineering changes and re-published. An additional six copies of the revised test procedures and one reproducible will be delivered under Phase III.

B. Phase III Program

1. Class 1 Drawings

Work on the Phase III class 1 drawings commenced 17 April 1961. At the end of this report period, work on these drawings was on schedule and progressing satisfactorily.

2. Manufacturing

The following quantities of alarms and remote warning units of the AAI drawing numbers indicated are scheduled for delivery under the Phase III program of the subject contract:

3862-040299-10	Qty 9 E41R1 Alarms
3862-040300-10	Qty 16 E41R1 Alarms
3862-040188-10	Qty 23 Remote Warning Units

Metal threaded inserts have been added to six alarm cases by CWL for use in the assembly of the first group of Phase III alarms listed above. The purpose of these metal inserts is to render the cases waterproof at the points of hardware attachment.

Of the 16 alarm cases in the second group listed above, two have been received from the vendor to date. A preliminary examination of these cases indicated they are of acceptable quality and workmanship. These cases incorporate integral

Fiberglas blocks around the threaded hole portions of the attachment points for waterproofing purposes. These blocks are intended to forestall leakage difficulties encountered in previous immersion tests, as reported in Engineering Progress Report ER-2338.

The AAI production drawings for these Phase III alarms and remote warning units have been prepared and released and detail parts are currently being fabricated.

C. Research and Development Program

1. Air Pump Assembly

During previous research and development tests on existing alarms, it was found that an accumulation of residue from the solution tends to form on the internal surfaces of the air pump assembly. In an effort to combat this deposition, a modified air pump incorporating a valve configuration perpendicular to the pump stroke wherein the intake valve is mounted vertically at the top of the pump head chamber and the outlet valve at the bottom. This pump was tested alongside a pump of the original design for a period of 186 hours. The solution used during this accelerated test was three times as concentrated as that used in normal alarm operation, i.e., 33 ml of water was mixed with 30% ODN, as compared to 100 ml of water used in alarm operation. The concentration of peroxide in the solution was proportionately greater. The test was halted when the pump of the original design configuration underwent considerable drive motor degradation. (The current drain rose from 85 milliamps to 142 milliamps in an 80-minute period.)

As a result of this test, it was found that considerably less deposition was experienced in the newly-designed pump head than in the original design. The amount of residue was calculated by weight, as follows:

ORIGINAL PUMP CONFIGURATION		NEWLY-DESIGNED PUMP CONFIGURATION	
Exhaust Fitting	6.8 mg	Exhaust Fitting	0.9 mg
Exhaust Valve Set	2.4 mg	Exhaust Valve Set	0.5 mg
Diaphragm	2.2 mg	Diaphragm	1.2 mg
Inlet Fitting	7.6 mg	Inlet Fitting	0.5 mg
Inlet Valve Set	4.9 mg	Inlet Valve Set	0.9 mg
TOTAL ACCUMULATIONS 23.9 mg		5.6 mg	

A third pump configuration incorporating a double-valved pump head, designed by CRDL, will be subjected to a similar test in the near future.

2. Electronics

a. Radio Interference

On 24 April 1961, a Phase II design alarm was hand-carried by AAI personnel to the Alltronics Co., Westbury, Long Island for radio interference tests by H.P. Westman. The unit was tested to determine whether or not it meets the class III requirements of MIL-I-11748B, which limits radio frequency (rf) interference within the range of from 0.015 to 1,000 megacycles (mc). During the course of these tests, excessive interference from the various components of the alarm ranging from 40 to 300 mc was detected. The primary sources of the excessive rf interference were:

- (1) The alarm horn
- (2) The air pump drive motor
- (3) The Brailsford tape drive motor (minor interference, only)

Efforts were begun shortly before the end of this report period to eliminate the excessive rf interference in order to bring the alarm into compliance with the specification.

b. Air Inlet Heater Control Circuit

Modifications were made to the air inlet heater control circuit as follows:

- (1) A newly-designed heater was substituted for the original unit.
- (2) A 2% thermistor was substituted for the original unit in the photometer head.
- (3) Resistor R34 was connected to the -18 volt regulated circuit, instead of the -24 volt protected circuit.

With these modifications, the air inlet heater will maintain a temperature of more than 75° F at the thermistor when the ambient temperature drops from room temperature to -40° F. With the addition of this higher possible temperature, the tape temperature can be brought up to 70° F when the thermistor temperature is 75° F. When the alarm is operated under these conditions, the potentiometer R14 must be adjusted to give 5 volts at the heater.

c. Alarm Flasher Circuit

The alarm indicator light flasher circuit has been taken from the -24 volt protected circuit and connected to the -18 volt regulated circuit. In addition, the value of R28 has been changed so relay K1 pulls in consistently. The lamp remains in the -24 volt circuit.

d. General

During this report period, a study program was instituted with the goal of achieving improved temperature and voltage stability of the low-voltage cutoff, the regulated voltage, and the alarm light oscillator circuits. Modifications to these circuits, and possibly to other circuits, as the need arises, will be made and tested as time permits. To date, no actual circuit modifications have been accomplished as a result of this study program, but it is anticipated that such changes will be incorporated into the alarm design as their feasibility is determined.

3. Fluid Pump

The fluid pump tests discussed in the previous Engineering Progress Report, ER-2338, were continued during this report period. The objective of these tests is to devise a fluid pump which will deliver between 0.37 and 0.39 milliliters (ml) of solution per cycle of the alarm, both at room temperature and at temperatures as high as 140° F, with a high degree of reliability. To achieve this end various flexible tubes have been tested, some of red and white silicon rubber and others of

black natural rubber, with varying lengths to give a variety of tube tensions. Both two-roller and four-roller configurations were tested, but little difference in results was observed. An experimental configuration in which the tube is restrained by a back-up plate was also tried. This supported-tube configuration delivered 0.5 ml/cycle of solution at room temperature. Further tests will be performed in the near future in order to determine the full potential of this configuration. Still other tests have been performed on pump tubes of red silicon rubber having a somewhat greater wall thickness than that of the white silicon rubber tubes previously tested, but no conclusive results have been obtained, to date.

The original fluid pump configuration adjusted to a 4-1/2 inch length of black natural rubber tubing, and with rollers separated a maximum of 1-3/4 inches (center-to-center) and a minimum mount distance of 2-17/32 inches has proven to be the most satisfactory tested. This system delivers 0.38 ml/cycle at room temperature and 0.36 ml/cycle at 140° F. Further tests will be conducted on this system to determine its reliability in operation over extended periods.

An accelerated fatigue test was begun on the red and white silicon rubber and the black natural rubber tubes. Each tube is stretched in a manner similar to that encountered in the actual alarm installation. The stretched tubes are exposed to the varying temperature and moisture conditions of outdoor weather. No visible test results were observed at the conclusion

of this report period. The test will be continued until an indication of the relative life span of the tubes can be determined.

4. Alarm Case

a. Alarm Cover Gaskets

As a result of the excessive leakage experienced in the vicinity of the cover latches during the immersion tests outlined in Engineering Progress Report ER-2338, a new type gasket incorporating a double-seal cross-sectional configuration and made of silicon rubber was developed by the Chemical Warfare Laboratory. This new type gasket will be produced by CWL and supplied to AAI. The gaskets will be forwarded to the alarm case vendor, who will install them on the case covers during production. The gasket, which is molded in one continuous piece to avoid seams, is recessed in the center so the inner and outer edges comprise two separate and distinct seals.

b. Controls and Instruments Gaskets

During the immersion tests referred to above, it was also determined that the gaskets previously used under the controls and instruments mounted on the top panel of the alarm (and of the remote warning unit) were not thick enough to provide absolute watertight protection. In order to correct this shortcoming, CWL has developed a silicon rubber material, which is forwarded to AAI in flat sheets for fabrication into the proper shapes to be installed into the alarms.

c. Fluid Pot Gasket

In an effort to remove reagent materials from the sampled air before it passes through the vacuum pump, a filter has been added to the fluid pot top gasket assembly. The reagent present in the air has a tendency to evaporate in the pump, leaving a white residue under the flapper valves, thereby adversely affecting pump efficiency and eventually leading to a complete breakdown of pump operation. To achieve this end, the original AAI fluid pot top gasket was modified to incorporate an integral air filter holder in a one-piece molded gasket. This gasket is presently being provided by CWL for inclusion in the phase III alarms.

5. Transportability

In order to facilitate the transportation of the alarm, a "D"-ring has been added to the carrying handle shoulder bolts. Two diametrically opposite radial holes have been added in these bolts to receive the pivot ends of the "D"-rings. In use, a canvas or other suitable strap can be attached to the "D"-rings to form a shoulder sling or to mount the alarm on a vehicle pack rack.

6. Impact Tests

On 19 April 1961, a series of impact tests were conducted to check the function of the tape transport system snubber consisting of a tang on the drum retracting lever holding spring. For the purpose of these tests, a wooden mockup of the alarm case was constructed, simulating the center panel of the alarm. A

total of three drops were made from a height of 14.5 feet onto a concrete surface. The results of these drops were as follows:

a. Drop No. 1

Tape drum retracting lever snubber tang failed to function, allowing the tape transport assembly to retract to the fully-down position and to be locked down. The stop bar which was attached to the solution pot (to transmit the load of the pot during impact to the latch handle) was successful in its function; however, this led to the failure of the pot retaining mechanism at the handle pivot pins. These pins were sheared off at the support brackets, even though the solution pot was empty during the drop test.

b. Drop No. 2

Before the unit was dropped a second time, the snubber tang was adjusted to more positively engage the drum retracting lever. As a result, the snubber functioned satisfactorily during the second drop test.

c. Drop No. 3

When the unit was dropped the third time, the snubber tang was sheared off and the tape transport system was locked in the retracted position.

As a result of the above tests, a new tape drum retraction snubber was designed which embodied considerably stronger components and a system which is inherently stronger than the previous snubber. A total of 25 drops were made from a height of

14.5 feet, resulting in completely successful operation of the snubber every time.

In order to prevent the fluid pot from engaging the front edge of the header as it returns to its normal position after retraction due to impact, a pad was added to the front cover of the alarm case. This pad prevents the pot from kicking outward as it retracts and guides the pot back to its normal position as it is pulled back up by the retainer springs.

7. Vacuum Sensor (Barometric) Switch

Modifications to the air pump energizing circuit have resulted in modifications to the barometric switch originally designed for use in the alarm. The modified vacuum sensor has only one sensitive switch, instead of the original two, to sense a low-vacuum condition (figure 1). The newly-designed vacuum sensor is accurate to within 1/8-inch of mercury throughout a range of from 0 to 5-1/2 inches. It can be adjusted by rotating the top cap (see figure 1). Operational tests which are presently being performed will be continued in order to fully evaluate the operation of this switch before it is incorporated into the alarm design.

8. Tape Transport System

a. Tape Drum Spring

Efforts to improve the original tape drum return spring were continued during this report period. The primary goal of these efforts was to produce a spring which will provide the 2-1/2 pound pressure which was previously determined to be

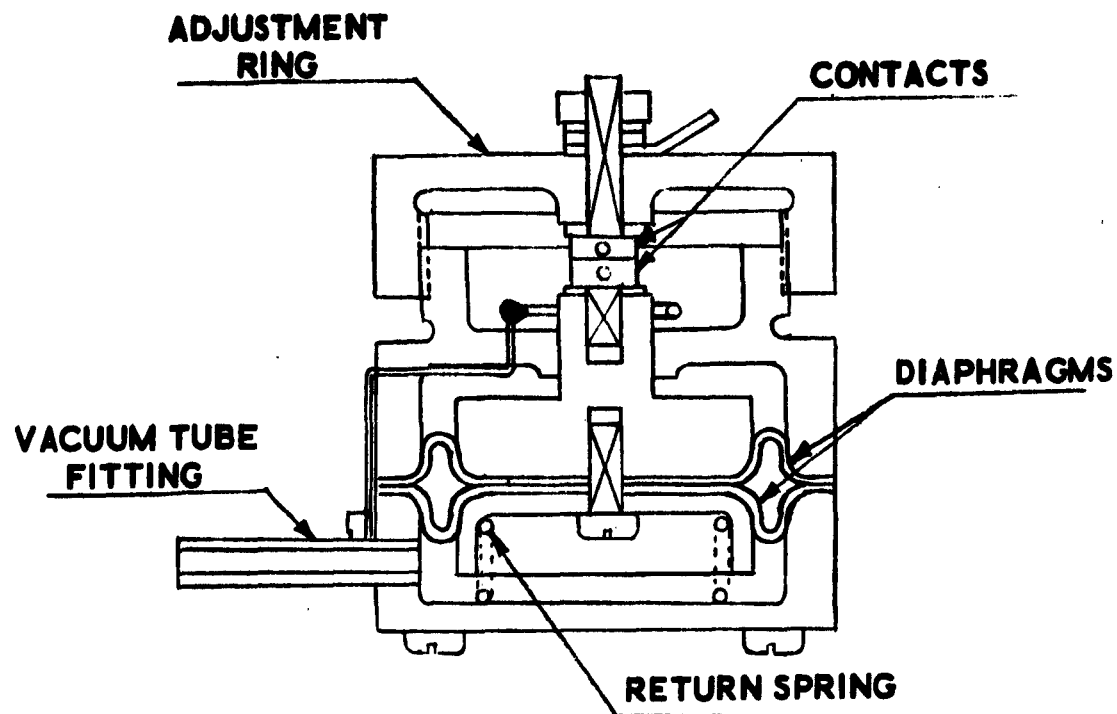


Figure 1. Modified Vacuum Sensor Switch

optimum (see Engineering Progress Report ER-2338), yet will not oxidize under adverse climatic conditions nor take a "tension set" from being extended for prolonged periods. Sample springs were fabricated from ARMCO 17-7 PH stainless steel wire. One of the sample springs was subjected to a preliminary two-day tension test. When checked, the spring still exerted the original 2-1/2 pounds of tension. At the end of this report period the sample

was in the process of being subjected to a one month fatigue test. If constant results of 2-1/2 pounds of tension are achieved from this special stainless steel spring at the completion of these tension tests, this spring will be adopted for use in future gas alarms.

b. Control Circuits

Five alarms undergoing pre-delivery tests (serial nos. 9, 15, 17, 22, and 30) and three alarms returned from the Army Chemical Corps (serial nos. 14, 21, and 26) were utilized for further research and development of modified electronic circuits as follows:

1. Brailsford and Haydon tape drive motor tests.
2. Relay circuits for use with the Haydon motor were incorporated in order to:
 - a. Eliminate need for excessively close adjustment of S2 and S3.
 - b. Stop timing motor during malfunction.
 - c. Stop vacuum pump drive motor during the tape transport cycle.
3. Revised S2 and S3 circuit from a series hookup to parallel. (This accomplishes the results obtained in 2, above, when used with the Brailsford motor).

Since part of the difficulty experienced with the original tape transport system stemmed from variations in motor

speed due to changing input voltage, one proposed method of controlling the transport time is to add a regulated voltage circuit capable of producing motor-energizing voltage limited to from 20 to 23 volts in range. In this manner, the speed of the motor can be regulated to within suitable tolerance. An experimental voltage regulator has been fabricated, but it has not yet been tested. The use of the Brailsford motor eliminates the need for dynamic braking, hence the feasibility of employing the parallel hookup of S2 and S3. By operating this motor on the existing 17.5-volt regulated power supply, its speed can be closely controlled.

c. Motors

(1) Configurations

Several different tape transport system drive motors are currently undergoing research and development tests, as well as revisions to the motor energizing circuit (through S2 and S3).

In order to determine the optimum tape drive system in a minimum of time, several methods are being tested simultaneously. The configurations are as follows:

Circuit No.*	Alarm Serial Number	Tape Transp. Motor	Voltage	Relay	Switch Hookup
1 (fig. 2)	9 & 17	18-Volt Brailsford	18	No	Parallel
2 (fig. 3)	27	H1-Torque Haydon	18	Yes	Parallel

Circuit No.*	Alarm Serial Number	Tape Transp. Motor	Voltage	Relay	Switch Hookup
3 (fig. 4)	13, 16, 22	Brailsford	24	No	Parallel
4 (fig. 5)	15 & 33	Haydon	24	Yes	Parallel
Standard (fig. 6)	11 & 28	Haydon	24	No	Series

In should be noted that CR-4 was removed from all alarm units for these tests.

* Refer to appropriate schematic diagram.

(2) Motor Tests

The various motor and circuit configurations were in the process of undergoing life tests at the end of this report period. Alarms numbered 9 and 17 are undergoing tests at AAI; the remainder of the units are undergoing similar tests at CRDL under the cognizance of AAI personnel. As of the end of this report period, all the alarms had been subjected to nearly continuous operational tests under varying environmental conditions for a period of two weeks. These tests will be continued until the results can be evaluated to establish the optimum configuration, from the standpoints of both durability and reliability.

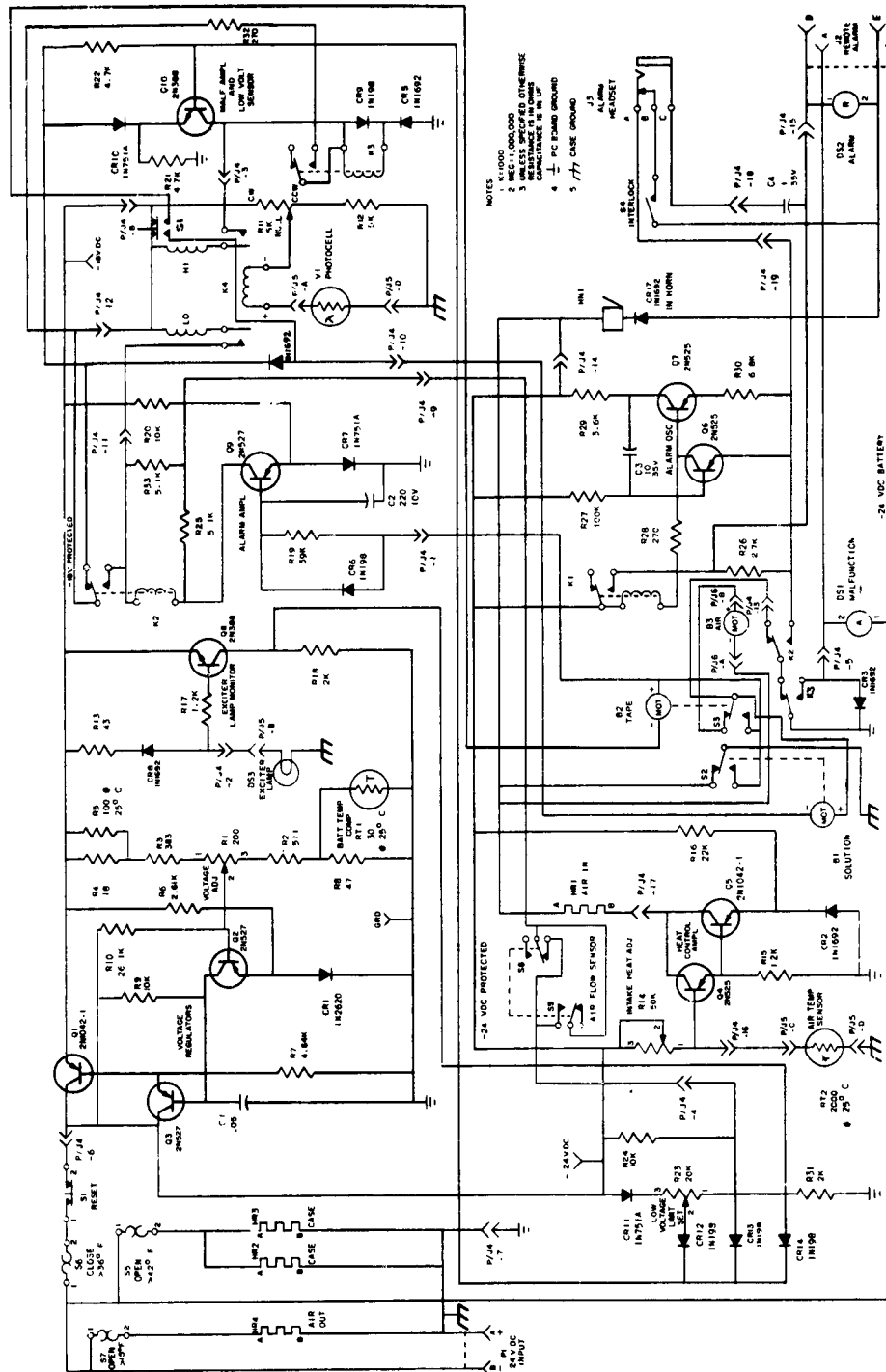


Figure 2. Modified Circuit Number 1, Schematic Diagram.

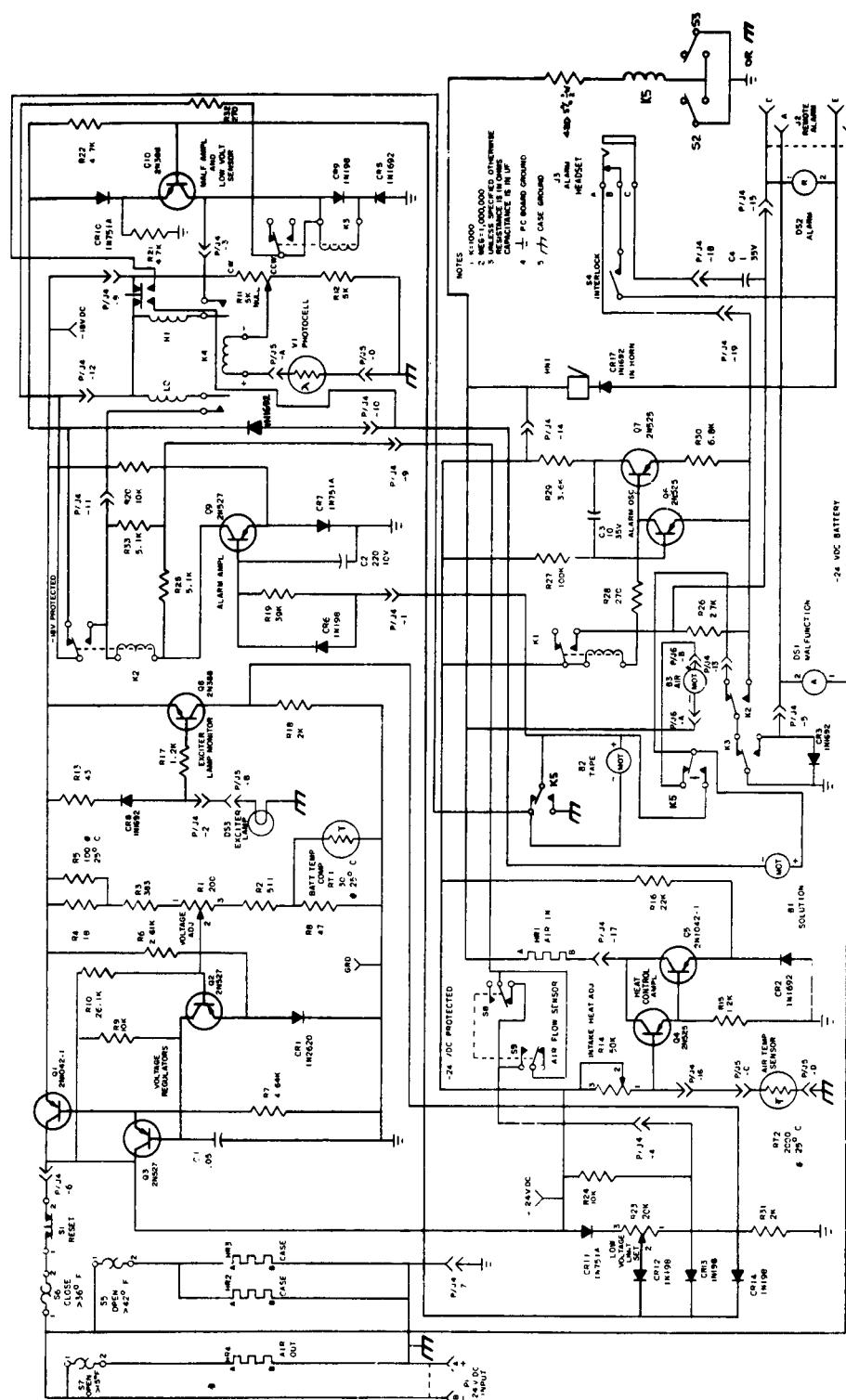


Figure 3. Modified Circuit Number 2, Schematic Diagram.

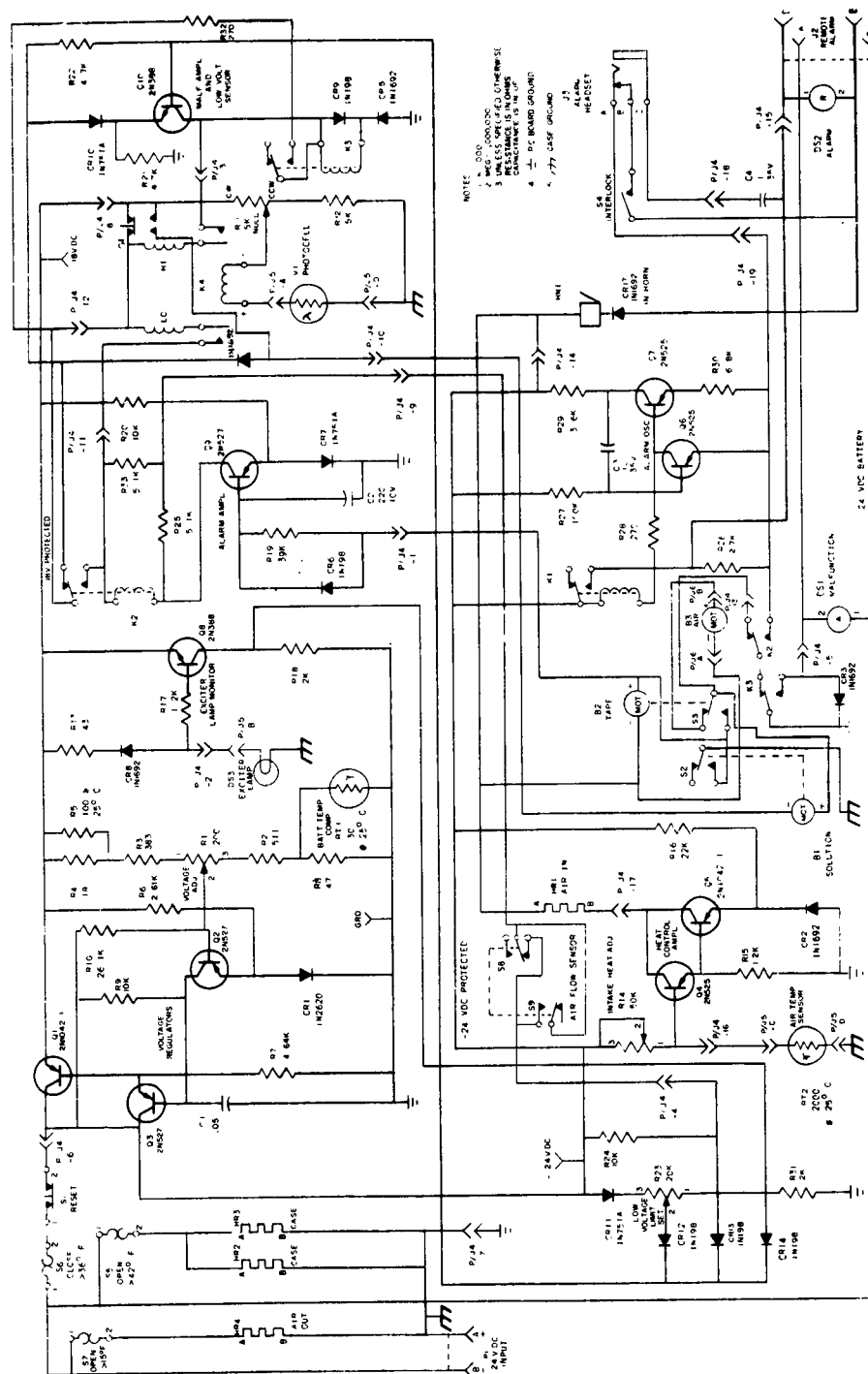


Figure 4. Modified Circuit Number 3, Schematic Diagram.

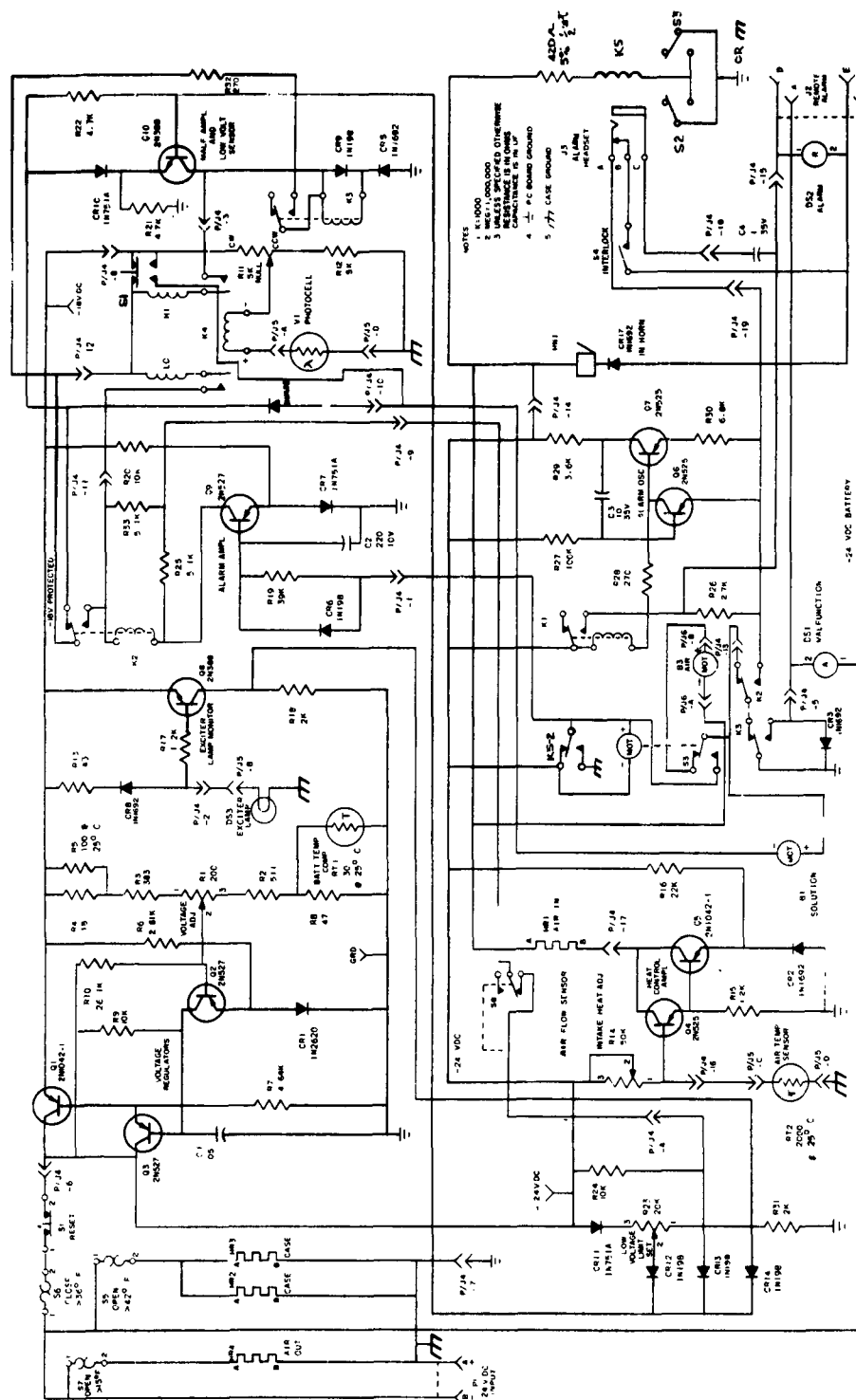
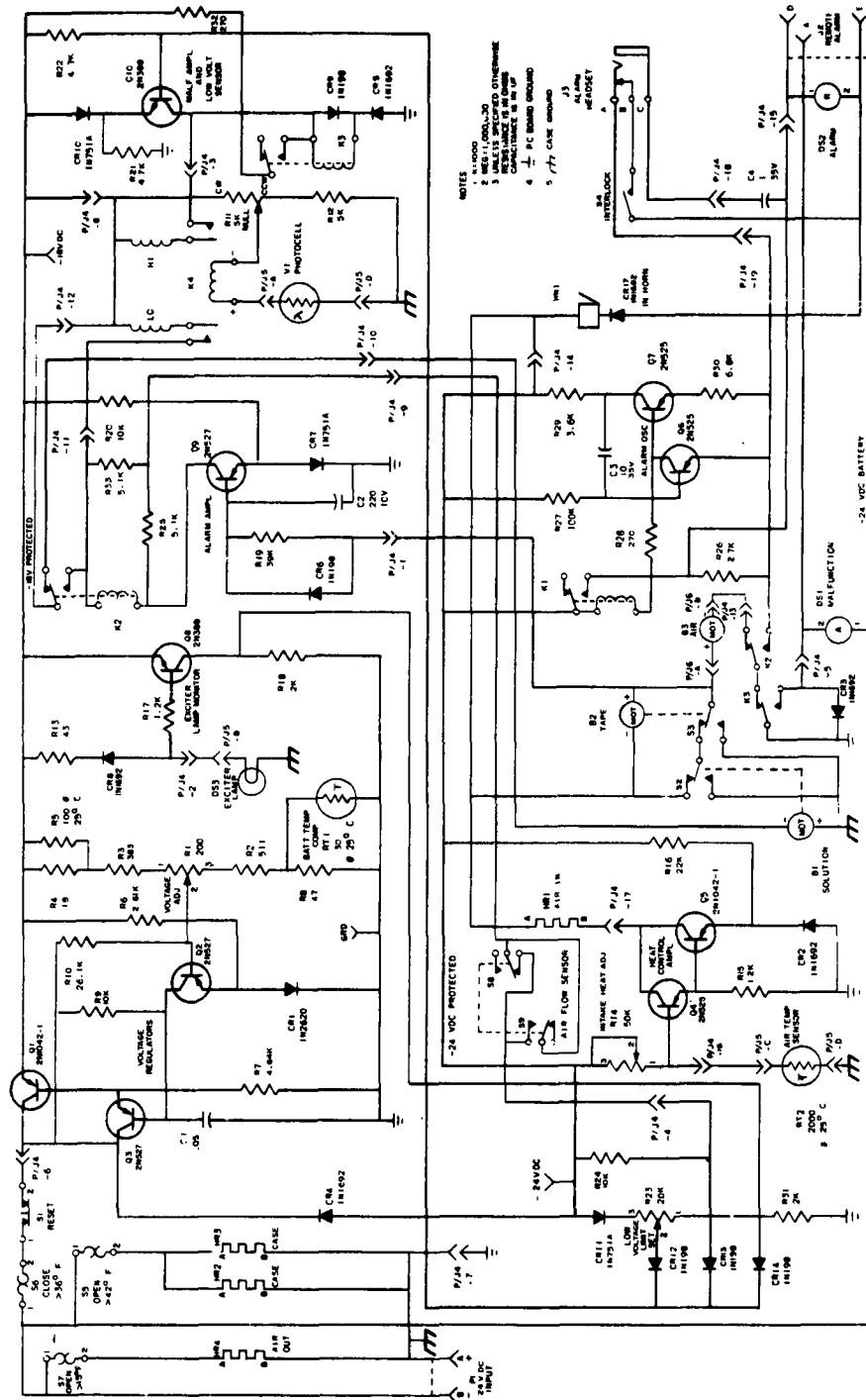


Figure 5. Modified Circuit Number 4, Schematic Diagram.



9. Applied Chemistry

An AAI engineer has conducted close liaison with CRDL alarm branch personnel in order to ascertain the precise level of sensitivity to be met by the E41R1 alarm and to coordinate the efforts of the AAI chemical laboratory with those of the Army Chemical Center chemicals branch. The concentrations of GB agent produced by the AAI gas generator were analyzed carefully and readings taken in order to facilitate the coordination effort with ACC.

In addition, during this report period automatic drying apparatus was installed in the air supply line to the gas generator at AAI.

During the coming report period efforts will continue to ascertain that CONARC requirements of the chemical aspects and gas sensitivity performance of the alarm have been met. Further effort will be expended to determine the theoretical validity of the solution peroxide concentration, the ODN concentration, and to determine the gas-solution reaction temperature limits.

10. Photometer Head

a. Test Fixture

For the purpose of determining the performance characteristics of the individual photometer head components, a special test fixture was constructed on which the exciter lamp, the filter, and the photo cell can be mounted. On this fixture, the environmental temperature of the components can be varied

from room temperature to 176° F while the photo cell current output is monitored.

b. Photo Cell Tests

The photo cells were tested by using a heavy-filament stabilized exciter lamp which provides a constant illumination output. The photo cell output current was then recorded as the cell was subjected to varying temperatures for various periods of time. This record, when plotted as output current vs time, constitutes the drift curve of the cell output current for various temperatures. As a result of the photo cell tests, it was determined that the Clairex 602 photo cell presently in use in the E41R1 alarm is unstable at high temperatures and is unpredictable in performance. Tests on the Clairex 605L photo cell showed that it is a decided improvement over the 602; however, to provide the same degree of sensitivity as the 602 cell, a darker blue filter is needed. This, in turn, requires greater illumination from the exciter lamp in order to maintain the 100 microampere null point. Such a lamp was obtained and tested, as described in c, below.

c. Exciter Lamp Test

The T-1 1/4 exciter lamp produced by the Chicago Miniature Lamp Company was test-operated for a period of 100 hours to determine the extent to which aging affected its performance. As a result of this test it was found that after approximately four hours of continuous burning, the lamps

stabilized at an output which varied to the extent of a resultant -5 microampere change on the alarm meter-relay. This led to the conclusion that the maximum effect of aging of the exciter lamp presently in use during one continuous twelve-hour period of operation (after the initial 4-hour aging period) does not significantly change the lumen output of the lamp. (A stabilized photo cell held at constant temperature was used.) In addition, a special lamp (No. CM 8-721) was obtained from the Chicago Miniature Lamp Company. This lamp provides approximately five times more illumination than the T-1 1/4 lamp currently in use. Initial tests on this lamp indicate that its added illumination power adequately complements the 605L photo cell discussed in b, above

d. Spectrometer Tests

Further tests are being conducted by the use of a spectrometer to determine the actual spectral transmission reflected from the developed spot, wet tape, and dry tape, for the purpose of determining the optimum optical filtering to provide maximum detection from wet tape to developed gas spot.

IV. RE-EVALUATION OF BASIC DESIGN CRITERIA

It is the intent of AAI to review the design of the E41R1 Point Source Alarm for conformance to the approved Military Characteristics. A report of any progress along these lines will be included in future Engineering Reports submitted in accordance with the terms of this contract.

V. EVALUATION OF ALARM RELIABILITY

A study will be made of each component used in the alarm to determine that its life expectancy in this design application is compatible with the endurance and reliability requirements of the Military Characteristics.

VI. FUTURE IMPROVEMENT CONSIDERATIONS

Concurrent with the research and development tasks outlined above, evaluations will be made to determine those areas where improvement in the performance and reliability of component parts may be accomplished. It is further planned that a similar comprehensive evaluation of the entire alarm be made.